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EXAMINER	
JOHNSTON, PHILLIP A	
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**BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES**

MAILED

APR 0 7 2006

GROUP 2600

Application Number: 09/902,374
Filing Date: July 10, 2001
Appellant(s): ARCHIE, CHARLES N.

Mohammad S. Rahman
For Appellant

EXAMINER'S ANSWER

This is in response to the appeal brief filed 11-30-2005 appealing from the Office action mailed 7-26-2005.

(1) Real Party in Interest

A statement identifying the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

A statement identifying the related appeals and interferences, which will directly affect or be directly affected by or have a bearing on the decision in the pending appeal is contained in the brief.

(3) Status of Claims

The statement of the status of the claims contained in the brief is correct.

(4) Status of Amendments After Final

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

(5) Summary of Claimed Subject Matter

The summary of the invention contained in the brief is correct.

(6) Grounds of Rejection to be reviewed on Appeal

The examiner agrees with the statement of the grounds of rejection to be reviewed, as set forth in the brief.

(7) Claims Appendix

The copy of the appealed claims contained in the Appendix to the brief is correct.

(8) *Evidence Relied Upon*

U.S. Patent No. 6,388,253 to Su

U.S. Patent No. 6,616,759 to Tanaka

(9) *Grounds of Rejection*

The following Rejection is set forth in a prior Office Action, mailed 7-26-2005.

Claims Rejection – 35 U.S.C. 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 1-26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Su, U. S. Patent No. 6,388, 253 to Su, in view of Tanaka, U.S. Patent No. 6,616,759.

Su (253) discloses the following;

(a) Obtaining a focus exposure matrix of critical dimension (CD) waveforms and images as a function of stepper focus parameters, as recited in claims 1,3,4,6-11,14,

15,17,18,19,21,23,25, and 26. See Column 4, line 57-67; Column 5, line 1-24; and Figures 1A and 6B below;

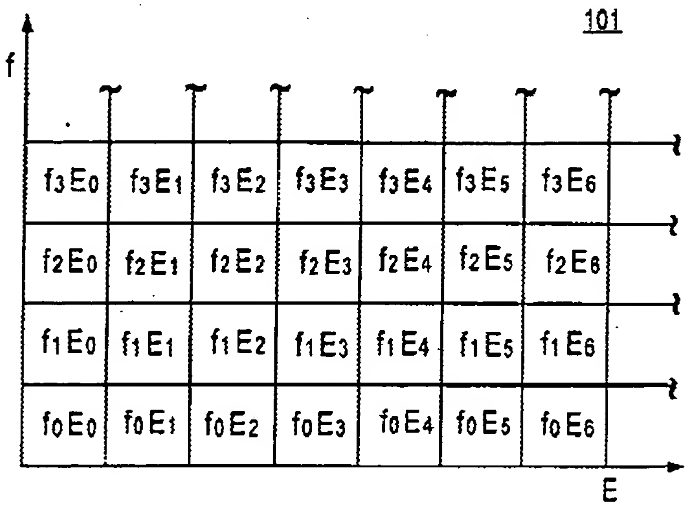


FIG. 1

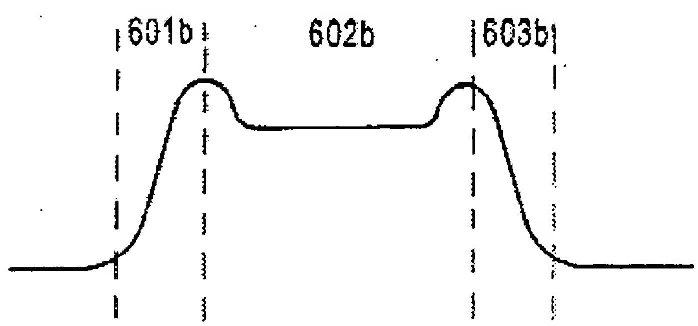


FIG. 6B

(b) Generating a library of reference features (approximate CD values) from the analysis of the matrix waveform data, as recited in Claims 1-4,6-8,10,12-15,17-23,25, and 26. See Column 4, line 12-45; and Column 5, line 6-57;

(c) Performing an analysis of the data to generate a "golden waveform", as recited in Claims 2-4,6-8,10,12-15,17-23,25, and 26. See Column 5, line 48-67; and Column 6, line 1-4;

(d) Comparing the target waveform to the "golden waveform" or one of the library of reference waveforms by using an algorithm to "fit a curve" as in Figure 6B above, thereby obtaining the best "matching score" or correlation (best fit), as recited in claims 1,8,10,12,19, and 20. See Column 10, line 26-42;

(e) Selecting a target feature, as recited in claims 2,13,19, and 21. See Column 6, line 5-21;

(f) Using plural parameters (at least three) to obtain a feature waveform including; CD as measured with a CD-SEM and/or AFM, as well as other sensitive parameters such as edge width and profile grade. The measured parameters are linked to photolithography adjustable parameters such as stepper focus and exposure settings, as recited in claims 1,8,10,12,19, and 20. See Column 3, line 52-67; and Column 5, line 20-39.

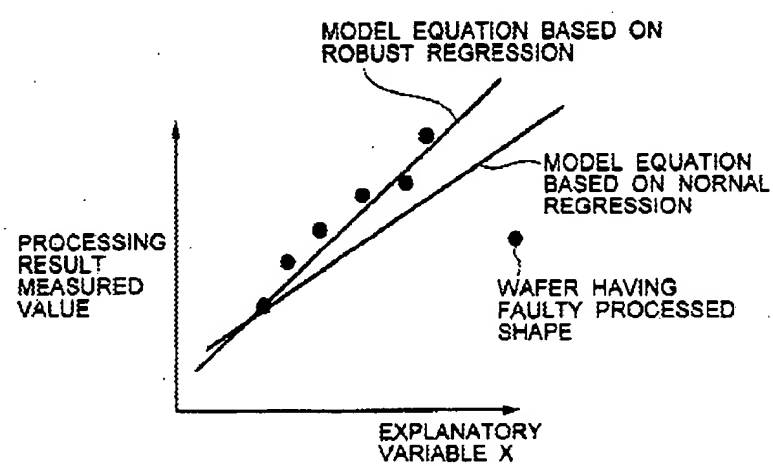
Su (253) as applied above fails to teach a method of calibrating the waveform data by determining at least three best-fit data parameters, and combining the best-fit data parameters with a stepper focus parameter and a critical dimension

measurement to improve the linearity of the critical dimension waveform, as recited in claims 1,8,10,12,19, and 20.

However, Tanaka (759) discloses a method of monitoring semiconductor manufacturing that includes the generation of a model equation from three parameters of sensed data, and using the best fit of the three parameters via multiple regression to improve linearity of the data. See Column 3, line 57-67; Column 5, line 5-37, and Figure 6 below.

It is implied herein that removing faulty process shapes in accordance with Tanaka (759) is equivalent to improving linearity, as recited in claims 1,8,10,12,19, and 20.

FIG. 6



Therefore it would have been obvious to one of ordinary skill in the art that the critical dimension apparatus and method of Su (253) can be modified to use the model

equation and regression method of Tanaka (759), to provide a robust regression method, to correct a prediction model equation by removing faulty process shape data, thereby controlling and/or monitoring a semiconductor processing apparatus while predicting its processing results.

(10) Response to Argument

The following is the Examiner's Response to Arguments contained in the Appeal Brief filed 11-30-2005.

1. Applicants Argument regarding the §103(a) Rejection of independent claims 1, 8, 10,12,19, and 20.

(a) Applicant states that, "Su in view of Tanaka fails to disclose, teach or suggest the features of independent claims 1, 8, 10, 12, 19, and 20.

Generally, the Appellant's invention teaches a method to improve and optimize the accuracy of the CD-SEM measurement that relies on either additional information in the waveform or other information coming from another distinct CD-SEM measurement or from another distinct non-CD-SEM measurement.

Conversely, Su assumes that the basic CD-SEM CD measurement is adequate for process control and thus forms the basis for process control. As such Su does not seek to improve or optimize the C-D value, which is contrary to the Appellant's invention. Su tends to focus on how to directly determine stepper focus and dose conditions by directly comparing target waveform to reference waveforms. As such, Su does not explicitly teach how to use additional waveform information to obtain a more

accurate CD measurement. Tanaka discloses a technique for controlling and/or monitoring a semiconductor processing apparatus while predicting its processing results, and thus even if combined with Su would still fail to teach all of the elements of the Appellant's claimed invention."

The applicant is respectfully directed to Su (253) Figure 1; Figure 2a and 2b below; Column 5, line 2-5; Column 5, line 27-55; and Column 6, line 55-65, which state; Specifically, the test wafer is exposed in a stepper while the focus is varied along one axis and the exposure is varied along the other. Thus, a matrix of features is obtained on the exposed wafer, wherein each exposure site or die has a different focus-exposure setting.

An evaluation of the CD, cross-sectional profile images, and other measured parameters is performed to determine the combination of focus and exposure settings, which produces the best feature characteristics. The reference waveform (i.e., conventional SEM waveform) corresponding to the combination of stepper focus and exposure settings that produced the best characteristics is then designated as a golden waveform. Each reference waveform is further associated with an etch recipe experimentally determined to be the optimal recipe to produce a finished feature (after etching) with a CD as close as possible to design dimensions, given the measured CD and other characteristics of the reference feature (i.e., the etch mask).

The concept of the reference library of the present invention is illustrated in FIGS. 2A and 2B. In FIG. 2A, which is based on the FEM of FIG. 1, the optimized process condition is represented by the cell marked "x". All other cells preferably cover a

reasonable range of process variation, or the "process window", wherein Δf_n and ΔE_m are each measured as the difference from cell x; that is, Δf and ΔE are both zero in cell x, and Δf and ΔE of the other cells are exposure doses and focus settings relative to the optimal exposure and focus. Each exposure column A-E represents a different etch recipe. Since the etch recipe adjustment applies only to CD, not profile, the etch recipes' assignments are aligned with the exposure columns. FIG. 2B represents an expansion of each cell of FIG. 2A. A measured CD value (e.g., in box I) and an SEM waveform (e.g., in box II) are linked within a cell to Δf_n and ΔE_m (e.g., in box III), to an etch recipe (e.g., in box IV) and to a cross section or image of the profile of the inspected feature (e.g., in box V).

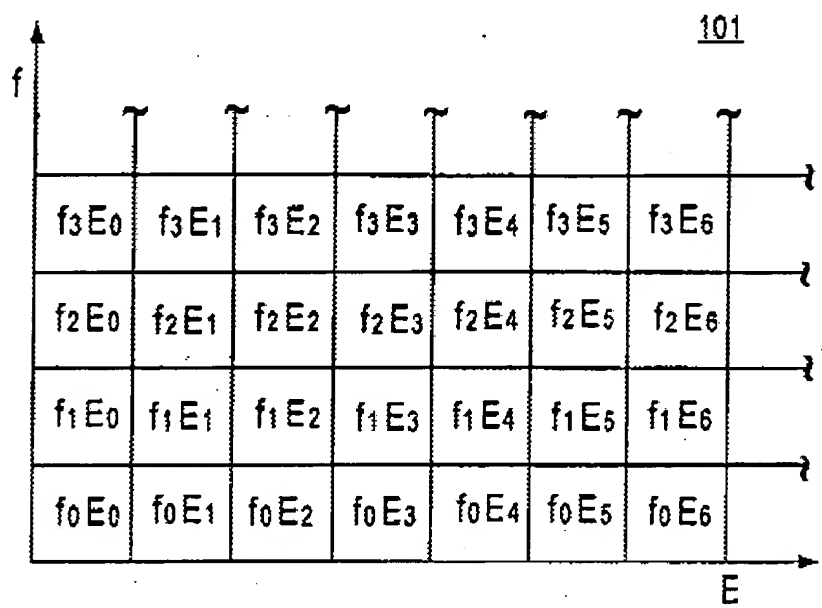


FIG. 1

A	B	C	D	E
$\Delta f_4 \Delta E_0$	$\Delta f_4 \Delta E_1$	$\Delta f_4 \Delta E_2$	$\Delta f_4 \Delta E_3$	$\Delta f_4 \Delta E_4$
$\Delta f_3 \Delta E_0$	$\Delta f_3 \Delta E_1$	$\Delta f_3 \Delta E_2$	$\Delta f_3 \Delta E_3$	$\Delta f_3 \Delta E_4$
$\Delta f_2 \Delta E_0$	$\Delta f_2 \Delta E_1$		$\Delta f_2 \Delta E_3$	$\Delta f_2 \Delta E_4$
$\Delta f_1 \Delta E_0$	$\Delta f_1 \Delta E_1$	$\Delta f_1 \Delta E_2$	$\Delta f_1 \Delta E_3$	$\Delta f_1 \Delta E_4$
$\Delta f_0 \Delta E_0$	$\Delta f_0 \Delta E_1$	$\Delta f_0 \Delta E_2$	$\Delta f_0 \Delta E_3$	$\Delta f_0 \Delta E_4$
A	B	C	D	E

FIG. 2A

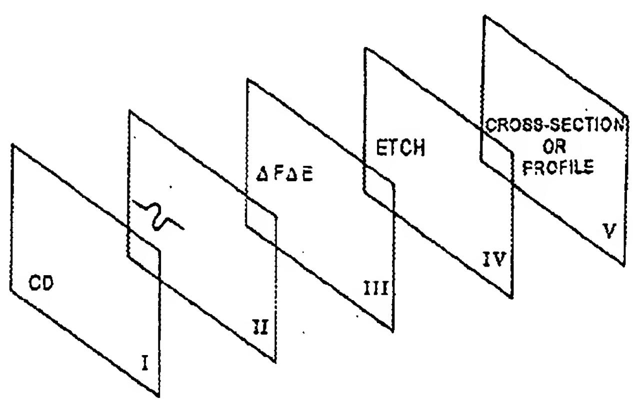


FIG. 2B

Next, dE and dF are compared to predetermined threshold values at step 470. If dE and dF are not greater than the predetermined threshold values, the CD and matching score of the target feature are reported at step 471, the data from the inspection is then sent to MES 350, and wafer W is sent to etcher 370. On the other

hand, if dE and dF are greater than the predetermined threshold values, the CD and matching score of the target feature is reported at step 480, along with dE and dF and the associated etch recipe, which is sent to etcher 370 to adjust (or "update") the etch recipe to correct the CD deviation of the finished features on wafer W.

The examiner has interpreted from the references above that Su (253) discloses generating a matrix of stepper focus variables as a function of measured CD values which is linked to etch process variables, for the particular purpose that these etch process variables produce the finished features (shapes) on a wafer for which the CD value is measured. Su (253) also shows that these etch process variables are the cause of CD error, and by creating a library of waveforms defined by CD/etch data, the resultant comparison of an unknown (target) sample feature by "best fit" to one of the library waveforms would define the stepper and etch variables which produced the unknown (target) sample feature. The difference between the target sample "best fit" library waveform and the "golden waveform" is then used to correct the drift in stepper focus and adjust the etch recipe to correct the CD deviation of the finished features on subsequent wafers being processed. In so doing, the Su (253) reference is specifically directed to obtaining an optimal critical dimension value, as recited in claims 1, 8, 10, 12, 19, and 20.

(b) The applicant also states that, "The Office Action (page 4) admits that Su fails to teach all of these elements, but nonetheless concludes that Su when combined with Tanaka teaches all of these elements. However, a close reading of Tanaka reveals that Tanaka does not teach what the Office Action purports it teaches, and

thus even if it were combined with Su, the prima facie case for rejecting the Appellant's application is deficient and improper. In fact Tanaka does not remove "structural bias parameters" from an approximate critical dimension measurement. The Office Action (page 5) indicates that Tanaka uses a best fit analysis in order to improve the linearity of the data. However, the Office Action assumes that Tanaka's removal of faulty process shapes is patentably analogous to Appellant's improved linearity. In fact, such a conclusion is erroneous.

Rather col. 2, lines 31-37 of Tanaka provide that Tanaka's technique monitors the processing state of a semiconductor process/apparatus to detect faulty processing based on the monitored results in order to improve thee process. Conversely, Appellant's invention generates an optimum critical dimension value based on the three best fit data parameters in combination with a stepper focus parameter. Accordingly, the Appellant asserts that the Examiner is improperly combining Tanaka with Su and is making assumptions (i.e., Office Action states, it is implied herein...") regarding Tanaka in an effort to try and teach the Appellant's claimed invention. Furthermore, there would simply be no motivation to combine Su with Tanaka because one of ordinary skill in the art would not have made the assumption (i.e., see implied language on page 5 of the Office Action) that was made in the Office Action."

The applicant is respectfully directed to applicants published specification Figure 2; and Figure 10 below; paragraphs [0009] - [0011]; [0043]; [0044]; and [0053], which state;

[0009] As mentioned, the control of semiconductor manufacturing processes like

lithography and etching requires the ability to measure critical dimensions of features accurately and precisely. The trend to smaller geometries and more complex designs is challenging the capabilities of CD metrology instruments. On the one hand, the best critical dimension scanning electron microscopes (CDSEM) can show an acceptable single tool precision for many manufacturing levels. However, these same tools are failing to accurately measure the changes due to process drifts. This can result in both false positive (passing bad products) and false negative (failing good products) calls, which have serious financial impacts.

[0010] An example illustrating this problem is associated with FIG. 2. This figure shows CDSEM measurements of a post develop isolated raised structure (line) across a focus-and-exposure matrix (FEM) for two leading CDSEMs versus measurements from a respected reference measurement system (RMS). This is a particularly important geometry and material because it is similar to a key semiconductor processing step that determines the speed with which transistors can switch (microprocessor gate level). Tighter and more accurate control at this step of manufacturing can produce computer chips that are extremely fast and profitable. In this case, the RMS is a 2D scanning atomic force microscope (AFM). The AFM measurements identify the critical edge point as the bottom of the structure.

[0011] Ideally the data should lie along a straight line with unity slope and zero offset. The scatter of the data around the best fit line is an important measurement quality captured by a quality metric called nonlinearity. Quantitatively, this is proportional to the variance of the scatter. The nonlinearity is normalized such

that if all of the variance is due to the random measurement variance measured by reproducibility, then the nonlinearity equals unity. In this case, both CDSEMs have nonlinearities greater than 100. Both are disturbingly large numbers. The single tool precisions for these two CDSEMs are 1.5 nm and 1.8 nm, respectively. Those skilled in the art recognize that, currently, the necessary precision needed for isolated line control is 1.8 nm. The two instruments appear to satisfy this precision requirement but they fail to accurately track the critical dimension changes on the FEM.

[0043] Once again, what distinguishes the present invention from the prior art is the understanding that CD measurements inherent in the prior art are essentially corrupted due to consideration of structural characteristics, which are not relevant to the critical dimension, but which are highly sensitive to the stepper focus, such as sidewall angle. Fixing this problem leads to the present invention, whereby the prior art CD measurement is combined with focus monitor information in order to remove the undesirable component. This fixes the CD measurement accuracy, and can be accomplished using separate or embedded stepper focus information.

[0044] In the example of FIG. 2, the large nonlinearities are signatures of poor accuracy. This situation can be considerably improved by including knowledge of the stepper focus in the determination of the critical dimension value. In the case of this FEM the actual stepper focus is known for each exposure field. Using stepper focus and the RMS values, the SEM measurements can fit in a two variable linear regression by determining best fit parameters A, B, and C.

[0053] The open circles in FIG. 10 show the CD measurements using the preferred embodiment of this invention while the closed circles show the best prior art CD measurements. Even without calculating the nonlinearity metric for each case it is obvious that the preferred embodiment measurements are much better linearly correlated with the reference measurements from the RMS.

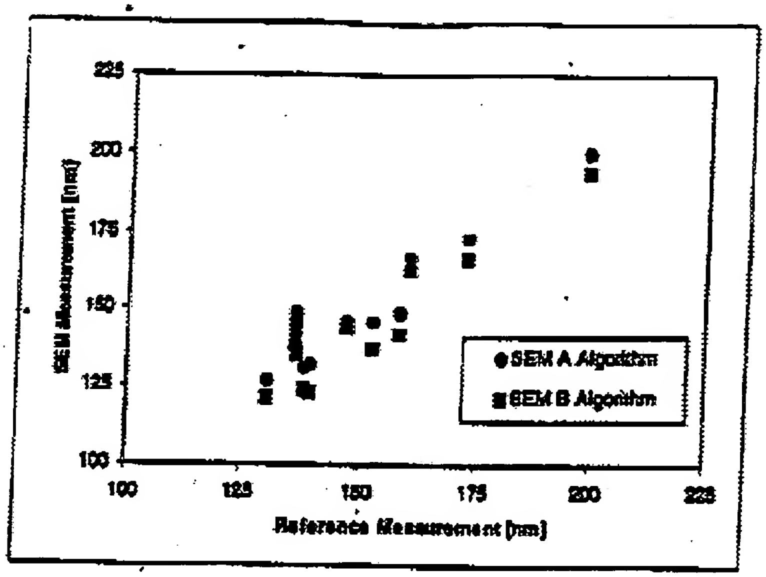


Figure 2

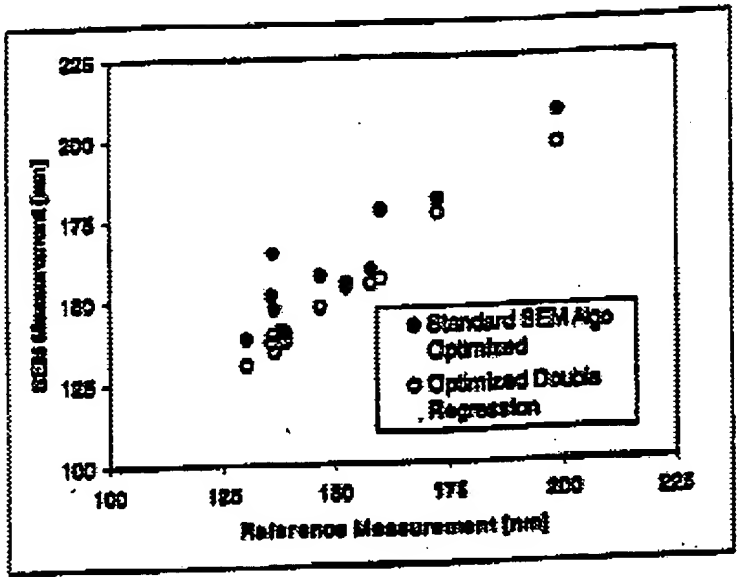


Figure. 10

The examiner has interpreted from the applicants specification referenced above that, creating a matrix (FEM) of CD vs. stepper focus variables can produce undesirable CD data, in particular the large nonlinearities shown in Figure 2, and that these large nonlinearities are the structural bias parameters to be removed, as recited in the claims. In addition, the structural bias is produced by variables associated with processes like lithography and etching. Further, the applicants use of the term "best fit" is defined with regard to the linearization technique of regression analysis and correlation of the variables used.

As a result, the examiner has concluded that the Su (253) reference above discloses each and every element of the claimed invention, including the "best fit"

limitation, with the exception of improving the linearity of the "best fit", which is provided by the Tanaka 9759) reference, as described below.

The applicant is respectfully directed to Tanaka (759) Column 4, line 61-67; and Column 5, line 1-35, which state; Some of the explanatory variable Xik are relied on to predict processing result measured values. Generally, since an explanatory variable Xil has the highest correlation to a processing result measured value Yi, Xi1, Xi2, Xi3 and so on are selected as explanatory variables. In the PLS method, a prediction equation such as the following Equation (2) is generated simultaneously. However, it may be better case by case to create the prediction Equation (2) using explanatory variables such as Xi1 mentioned above.

(2) Yi=p(Xi1, Xi2, Xi3) (2)

On the other hand, the processing result measured values may include data of wafers which indicate bad wafer processing states and therefore abnormal processing result measured values. A prediction performed using normal multiple regression for such data would result in generation of a model equation which has a low prediction accuracy due to the influence of abnormal data, as shown in FIG. 6. To avoid such low prediction accuracy, robust regression may be used for the prediction. With the use of the robust regression, a correct prediction model equation can be generated because abnormal data as shown in FIG. 6 are removed from data intended for prediction as outlier.

FIG. 7 illustrates a flow chart for explaining the model equation creation processing performed by the model equation generation unit 7.

When there are a large number of types of sensed data, the model equation generation unit 7 analyzes principal components of the sensed data (steps 701, 702), and performs the robust regression using the resultant principal components to predict processing results (steps 705-706). In this event, since explanatory variables include principal components which are not required for the prediction of processing results, so that principal components with a smallest regression coefficient is removed from the explanatory variable (step 707), one more principal component is added to the explanatory variables (step 704), and the multiple regression is again performed (step 706), as illustrated in the flow chart. This loop of processing is repeatedly executed until a prediction error is reduced below a predetermined value (step 708). These regression analyses may be linear, or non-linear regression analysis may be used as derived from physical characteristics and experimental values of the processing.

The examiner has interpreted from the references above that Tanaka (759) obtains CD measurement data and utilizes a partial least squares analysis technique that first establishes the explanatory variables to describe the process, and performs a first regression analysis to determine the linearity of their interactions, then removes the data points having the lowest correlation (worst fit), and repeats the regression analysis (robust regression) until the highest linearity (best fit) is obtained. In addition, it is the examiners contention that, one of ordinary skill in the art of CD measurement

would recognize that the applicants use of double regression (fig. 10) is equivalent to the Tanaka (759) multiple regression technique.

Finally, the examiner has interpreted from the Su (253) and Tanaka (759) references that the motivation to combine is that the intent of both Su and Tanaka is to obtain the "best fit " or "best correlated" results of CD measurements so that accurate process analysis and control can be obtained.

2. Arguments regarding the dependent claims 2-7,9,11,13-18, and 21-26, when read in light of the examiners response to the independent claims 1, 8, 10,12,19, and 20 are included in the above responses.

For the above reasons, it is believed that the rejections should be sustained.

(11) Evidence appendix

The statement regarding evidence contained in the brief is correct.

(12) Related proceedings appendix

The statement regarding related proceedings contained in the brief is correct.

Respectfully submitted,

PJ
April 3, 2006

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